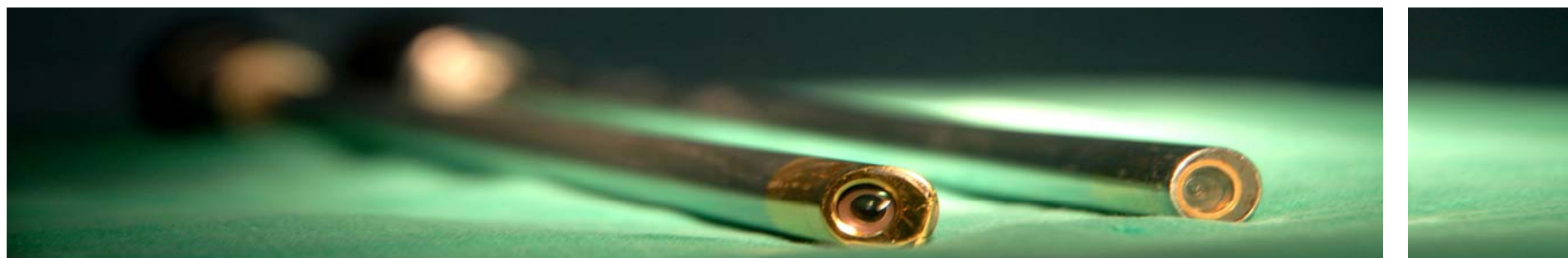




Basic Science in Laparoscopic Surgery



Suthep Udomsawaengsup, MD.
Laparoscopic and Bariatric Surgery



Contents

- Pneumoperitoneum
- Patient positioning
- Laparoscopic instrumentation
- Access into the abdomen



Laparoscopic Surgery

- Minimally Invasive Surgery (MIS)
- Keyhole Surgery
- Pinhole Surgery



Contraindication

- Uncorrected coagulopathy
- Inability to tolerate laparotomy
- Inability to tolerate general anesthesia
- Hypovolemic shock
- Uncompensated cardiopulmonary disease



Pneumoperitoneum

Mechanical effect (Primarily)

- 1. Upward displacement of diaphragm
 - ↑ Intrathoracic pressure
 - ↓ Diaphragmatic motion
 - ↓ Lung volume “↓ vital capacity, ↓ compliance”
 - ↑ Airway pressure “↑ peak, ↑ mean airway pressure”
 - ↑ Work of breathing



Pneumoperitoneum

Metabolic effect

- 1. CO₂ absorption

- Leads to hypercarbia and acidosis

- “In **healthy individuals**: **corrected by ventilation and body buffering system**”

- “In **COPD**: risk to develop hypercarbia

- Expired CO₂ (ETCO₂) levels are unreliable:

- arterial CO₂ needed**



Hypercarbia

- Moderate increase in PaCO₂ 15-30 mmHg produce a hyperdynamic state: SVR, CVP, HR and BP “no effect on CO”
- Marked increase in PaCO₂ > 30 mmHg: cardio depressive predominate, cardiovascular collapse, severe acidosis, fatal dysrhythmias
- Minute ventilation must be increased 20-30%



Hypercarbia

- Lowering IAP to **10-12 mmHg**
- Alternative gas : Helium
- Gasless laparoscopy
- Converted to open surgery



Pneumoperitoneum & Ventilation

Table 1

Ventilatory parameters in nine anaesthetized patients, without heart or lung disease scheduled for cholecystectomy, recorded in different body positions (horizontal and a head-up tilt of 15–20°) in the absence or presence of pneumoperitoneum.

	Horizontal	Pneumoperitoneum		
		Horizontal	Head-up tilt	Head-up tilt after 45 min
PI max (cmH ₂ O)	16 (5)	24 (4)**	22 (4)**†	22 (4)**
V _T (ml)	627 (174)	633 (150)	643 (151)	642 (152)
RR (breaths/min)	10 (0)	10 (0)	10 (0)	10 (0)
FiO ₂ (%)	35 (3.0)	36 (3.0)	36 (3)	36 (3)
ETCO ₂ (kPa)	3.6 (0.4)	4.1 (0.6)**	4.3 (0.7)**	4.4 (0.8)**†
PaO ₂ (kPa)	21.7 (5.9)	24.7 (4.8)**	24.2 (4.2)**	23.0 (4.6)
PaCO ₂ (kPa)	4.7 (1.0)	5.1 (0.8)**	5.3 (0.8)**	5.3 (0.8)**
PvO ₂ (kPa)	5.4 (0.6)	6.1 (0.9)**	5.8 (0.8)**	6.2 (0.9)**
P(A-a)O ₂ (kPa)	7.3 (5.7)	4.6 (4.1)**	4.9 (4.1)*	5.7 (5.4)
Arterial pH	7.46 (0.06)	7.40 (0.05)	7.39 (0.06)	7.38 (0.07)

Data are mean (SD); Intra-abdominal pressure (IAP)=11–13 mmHg.

*Significantly different from the horizontal position without pneumoperitoneum ($P < 0.05$); **Significantly different from the horizontal position without pneumoperitoneum ($P < 0.01$); †Significantly different from the horizontal position with pneumoperitoneum ($P < 0.05$).

PI max: max inspiratory pressure; V_T, tidal volume; RR, respiratory rate; FiO₂, fraction of inspired oxygen; ETCO₂, end-tidal carbon dioxide concentration; PaO₂ and PaCO₂, arterial partial pressure of oxygen and carbon dioxide, respectively; PvO₂, mixed venous oxygen tension; P(A-a)O₂, alveolar-arterial oxygen tension difference.

Acta Anaesthesiol Scand 2002; 46: 552–560



ETCO2



Ventilation change

- 1. High inspiratory airway pressure
- 2. Decrease FRC
- 3. Increase V/Q mismatch



Cardiovascular change

- Initially: $\uparrow$ venous return due to the blood volume sequestered in splanchnic vasculature
“Increase mean arterial pressure”
- Later on: $\downarrow$ venous return, $\uparrow$ arterial resistance , $\uparrow$ CVP
“ Resulted in compensatory $\uparrow$ HR”
“Net effect = no change in CO”
- IAP > 20 mmHg: IVC is compressed then venous return is impeded
- IAP > 40 mm Hg, venous return drop precipitously



Pneumoperitoneum & Cardiovascular

Table 2

Central haemodynamic parameters in nine anaesthetized patients without heart or lung disease scheduled for cholecystectomy recorded in different body positions (horizontal and a head-up tilt of 15–20°) in the absence or presence of pneumoperitoneum. Units = $\text{dyn} \cdot \text{cm}^{-5} \cdot \text{s}^{-1}$.

	Horizontal	Pneumoperitoneum		
		Horizontal	Head-up tilt	Head-up tilt after 45 min
HR (beats/min)	58 (10)	70 (14)**	74 (11)**	70 (11)**
MAP (mmHg)	66 (10)	92 (10)**	87 (15)**	76 (17)†
CVP (mmHg)	7 (3)	11 (4)**	4 (3)**†	6 (4)††
PCWP (mmHg)	9 (3)	14 (2)**	8 (2)†	9 (4)†
MPAP (mmHg)	13 (2)	18 (3)**	9 (2)**†	13 (4)†††
CI ($\text{l} \cdot \text{min}^{-1} \cdot \text{m}^{-2}$)	2.2 (0.4)	2.5 (0.6)	2.2 (0.6)	2.2 (0.5)
SVR (units)	1143 (276)	1758 (844)*	1656 (326)**	1447 (452)
PVR (units)	86 (50)	77 (50)	49 (36)	87 (49)

Data are mean (SD); Intra-abdominal pressure (IAP) = 11–13 mmHg.

*Significantly different from the horizontal position without pneumoperitoneum ($P < 0.05$); **Significantly different from the horizontal position without pneumoperitoneum ($P < 0.01$); †Significantly different from the horizontal position with pneumoperitoneum ($P < 0.01$);

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HR, heart rate; MAP, mean arterial pressure; CVP, central venous pressure; PCWP, pulmonary capillary wedge pressure; MPAP, mean pulmonary artery pressure; CI, cardiac index; SVR, systemic vascular resistance; PVR, pulmonary vascular resistance.

Acta Anaesthesiol Scand 2002; **46**: 552–560



Patient Positioning

- Head-down (Trendelenburg position)
 - ↑ Central blood volume and pressure
 - ↑ Cardiac output
 - ↑ Chest wall resistance, ↑ dead space
- Head-up
 - ↓ Venous return & Cardiac output
 - ↑ Femoral venous pressure
 - ↑ risk of DVT or pulmonary embolism



Pneumoperitoneum \$ Ventilation\$ Positioning

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Pneumoperitoneum & Cardiovascular & Positioning

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Arrhythmia

- Vagal reflex because of sudden stretching peritoneum with rapid insufflation provoke AV dissociation, nodal rhythm, sinus bradycardia and asystole
- Raise PaCO₂: **sympathetic response**
- Embolism
- Underlying cardiac disease



Renal Blood Flow

- Decreased RBF and GFR

Increase in renal vascular resistance, reduction in glomerular filtration gradient and decrease in CO

- Decreased urine output and insensible fluid losses



Renal Blood Flow & Pre-load & Pneumoperitoneum

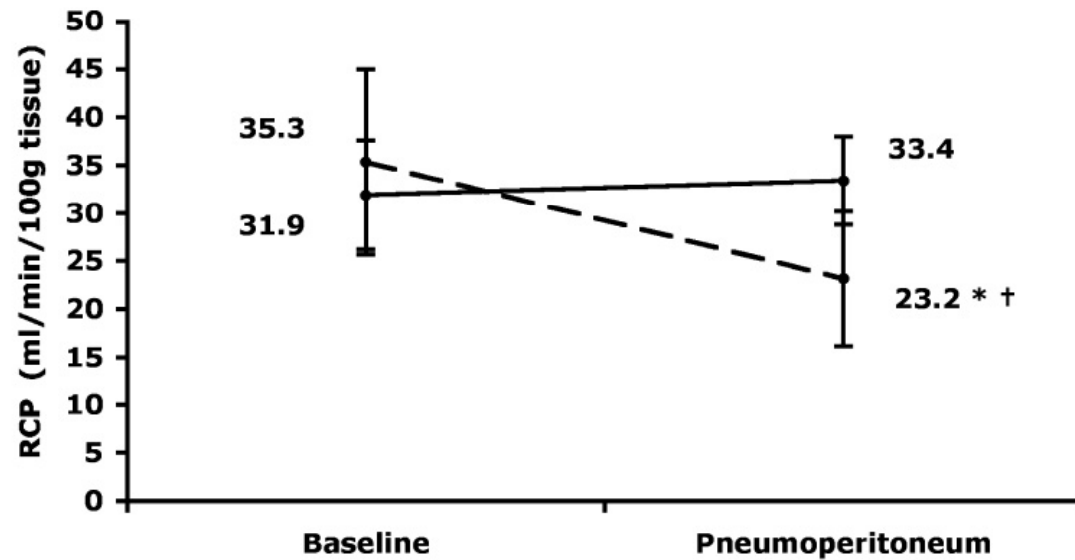


Fig. 3. Renal cortical perfusion at baseline and under pneumoperitoneum, stratified according to left ventricular end-diastolic diameter. Left ventricular end-diastolic diameter (LVEDD) ≤ 4.1 cm (dashed line), LVEDD > 4.1 cm (solid line); $n = 4$ for both groups. * $p < 0.05$ within group; † $p < 0.05$ between groups.

Surg Endosc (2006) 20: 794–800



Lactic Acidosis

- Elevation in IAP produces lactic acidosis, probably by severely lowering CO and impairing hepatic clearance of blood lactic acid



Intracranial and Intraocular change

- Increase cerebral blood flow from hypercarbia
- But increase intracranial pressure, intraocular pressure in the cases that have underlying diseases



Metabolic Effect of CO₂

Increase in PaCO₂

1. Absorption of CO₂ from the peritoneal cavity
2. V/Q mismatch
3. Impaired CO₂ excretion capacity (e.g., COPD, cyanotic CHD)



CO2 Emboli

- Presenting signs
 - Hypotension
 - Jugular vein distension
 - Tachycardia
 - Mill Wheel Murmur



CO2 Emboli

- Early (< 0.5ml/kg of emboli):
 - TEE CO₂ bubbling in right heart
 - splashing sound with precordial doppler
 - millwheel murmur
 - hypoxemia, high increasing PaCO₂,
 - high Δ PaCO₂-ETCO₂
- Late (>2ml/kg of emboli):
 - increase CVP, PAP
 - hypotension, arrhythmia
 - cardiac arrest



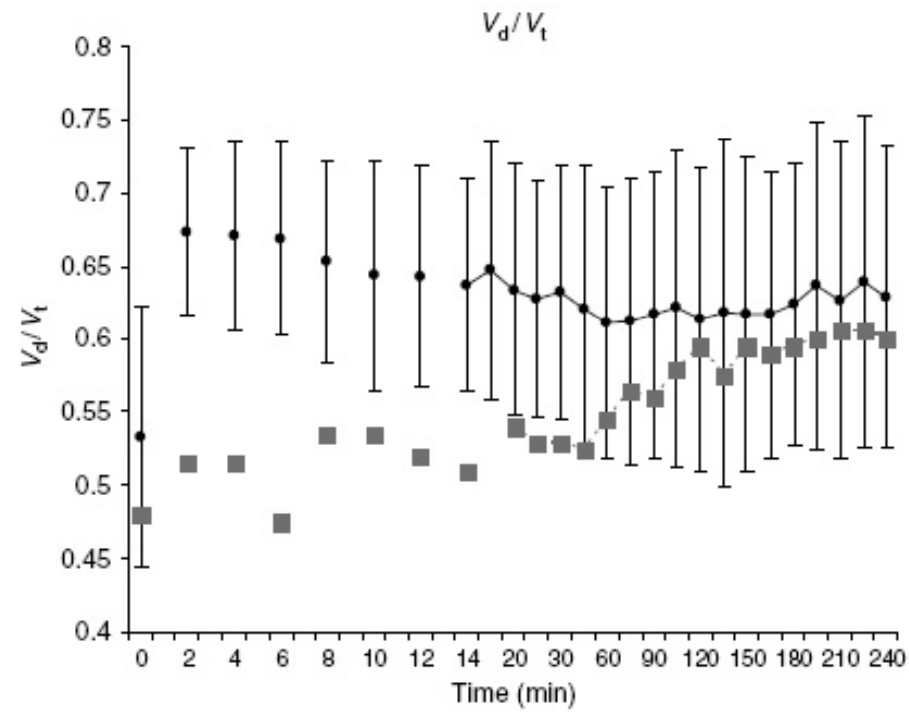


Fig. 2. Lung dead space/lung tidal volume (V_d/V_t) in the 4 h following CO_2 embolization, expressed as the mean $\pm$ standard deviation. The squares denote the mean of the two control animals.



CO₂ Emboli

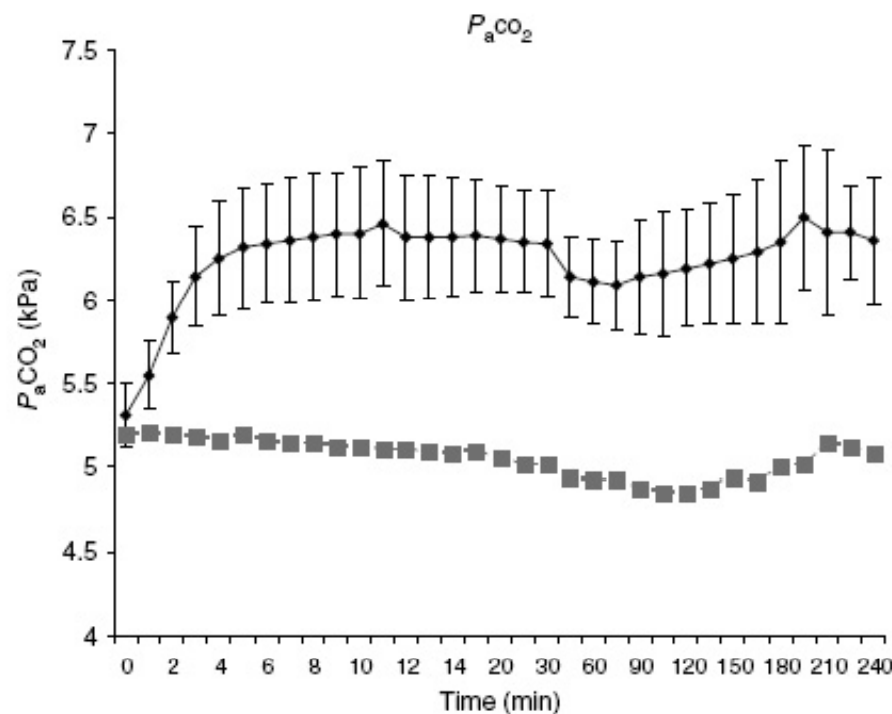
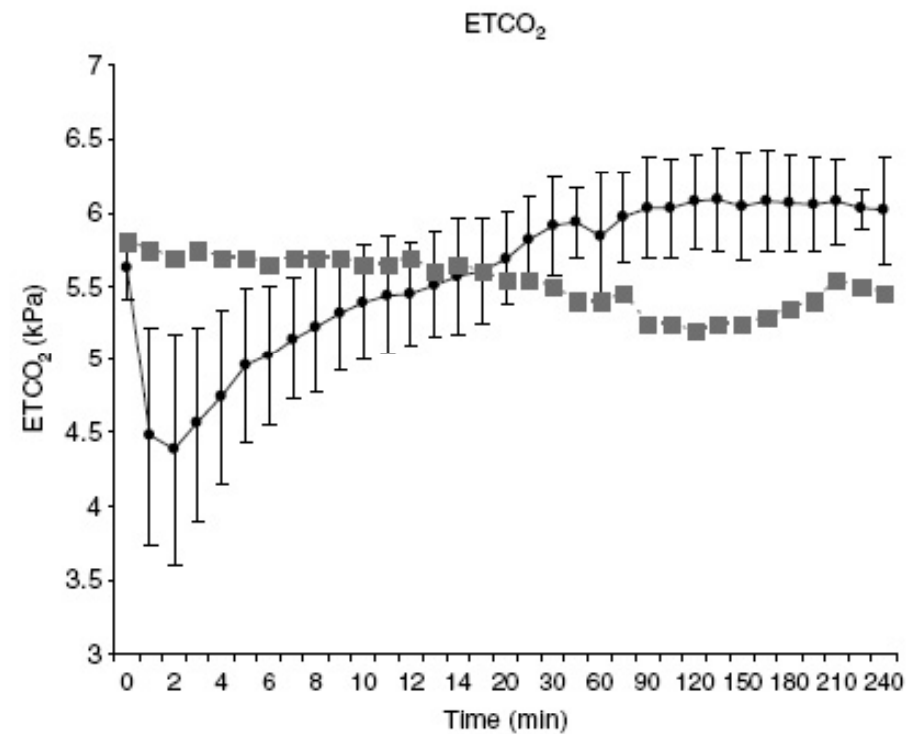


Fig. 6. Arterial carbon dioxide ($P_a\text{CO}_2$) in the 4 h following CO₂ embolization, expressed as the mean $\pm$ standard deviation. The squares denote the mean of the two control animals.



CO2 Emboli

- Treatment
 - Evacuate pneumoperitoneum
 - Left lateral decubitus , head down position
 - Introduce central venous catheter



Laparoscopic Equipment

- Laparoscopes
- Video Tower
- Gas Supply
- Suction Device
- Equipment Table

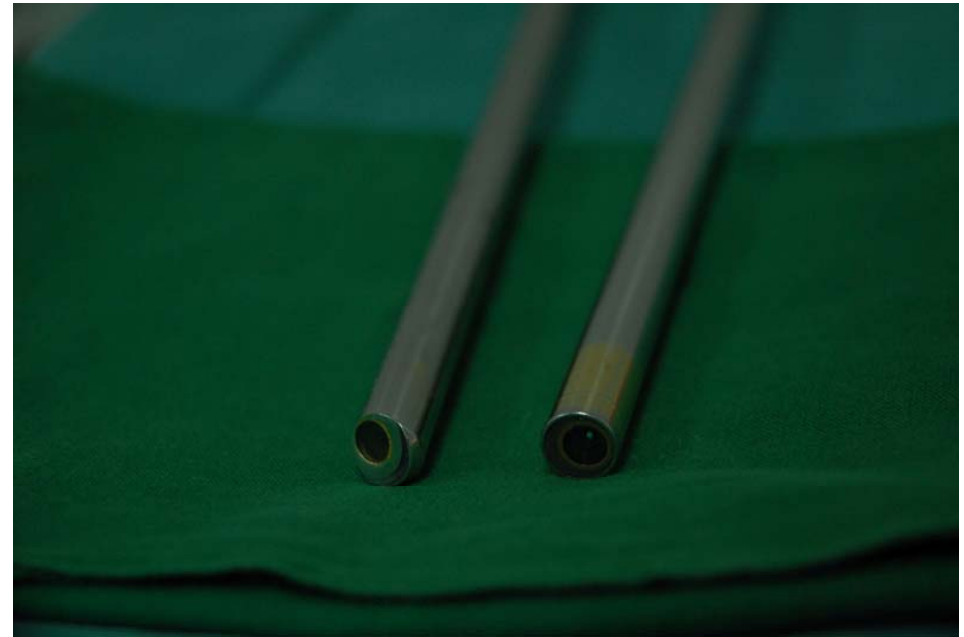
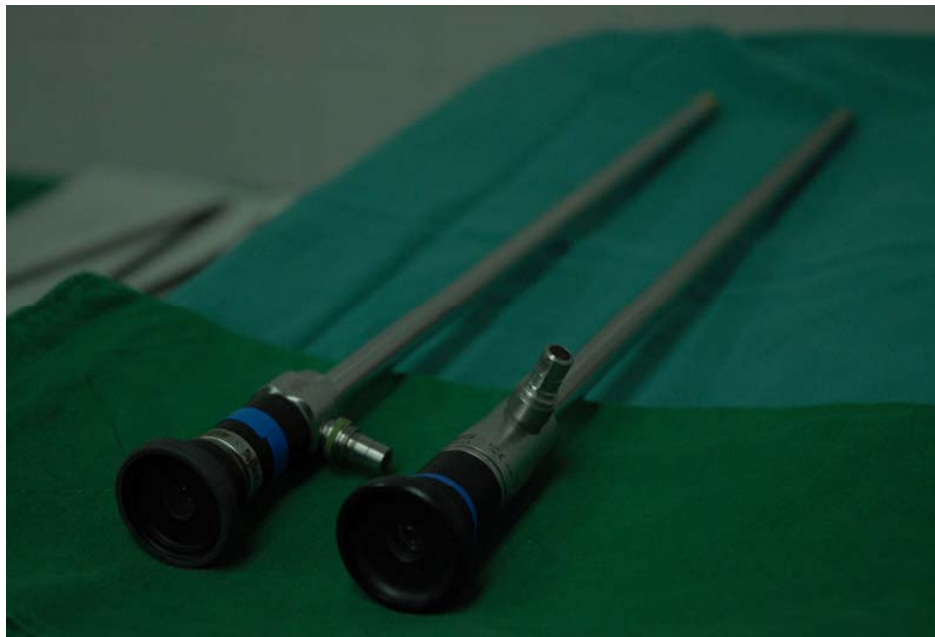


Laparoscopes



Laparoscopes

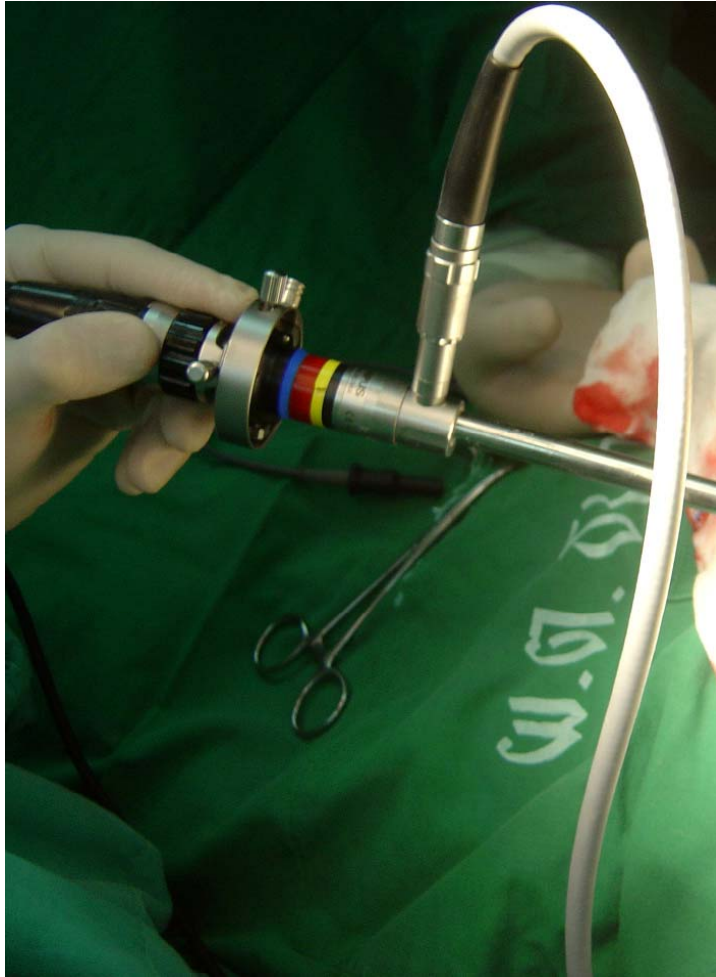
- Deliver light from a light source
- Conduct image to eyepiece



Laparoscopes



Video Tower



Light source

Light cable



Imaging systems

- Camera Head Unit



- Camera Control Unit



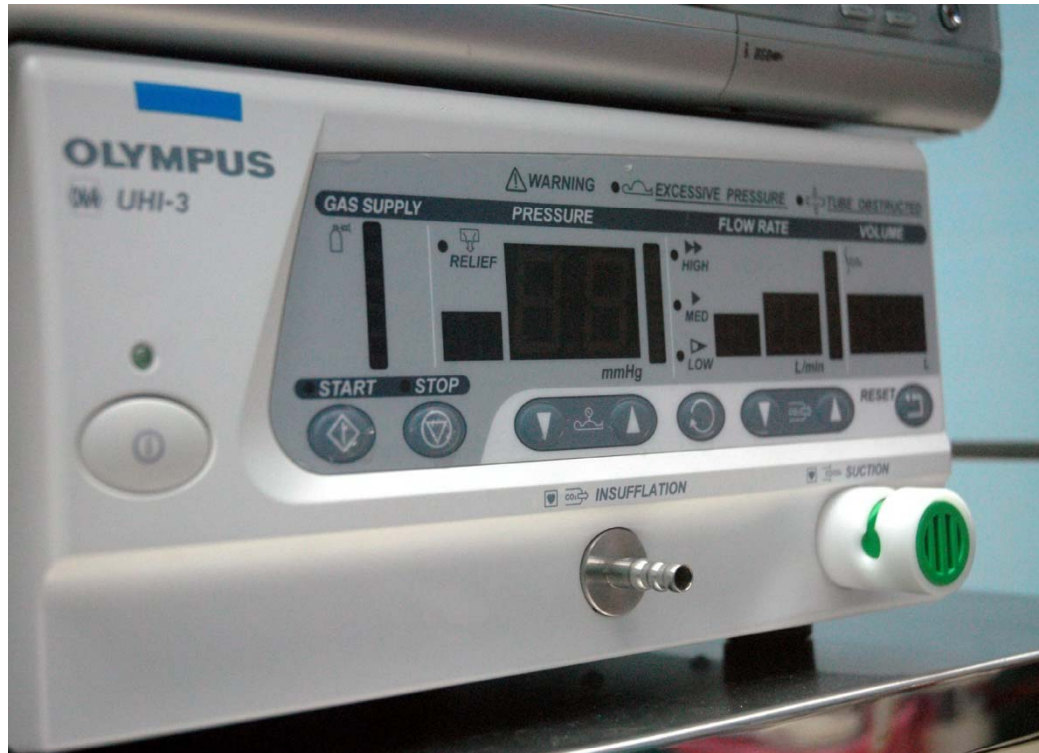
Gas Supply



- Gas tank
- Gas
 - CO2
 - Readily available
 - Inexpensive
 - Not support combustion
 - N2O
 - Helium



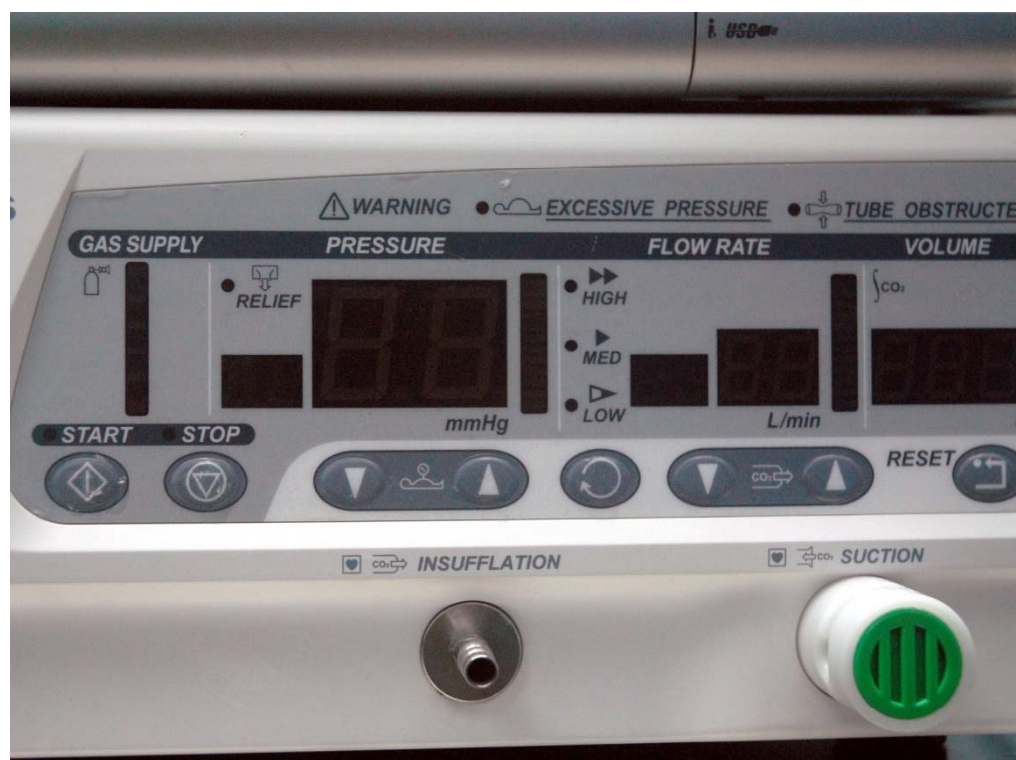
Insufflator



- Control the flow of gas from the cylinder to the abdomen
- High flow insufflator can deliver 10 or more liters of gas per minute and rate can adjust from low to high



Insufflator



Control panel

- Indication system listing the preset abdominal pressure
- The current abdominal pressure
- The flow rate of the gas
- Amount of gas used



Gas Supply

- A sterile line takes gas from the sufflator to the patient (Luer lock or push on tube)
- Some line have a filter in place



Suction Devices

- Multiple suction devices are needed
 - Anesthesiologist
 - Nasogastric tube
 - Laparoscopic instruments



Video Tower

- Video monitor



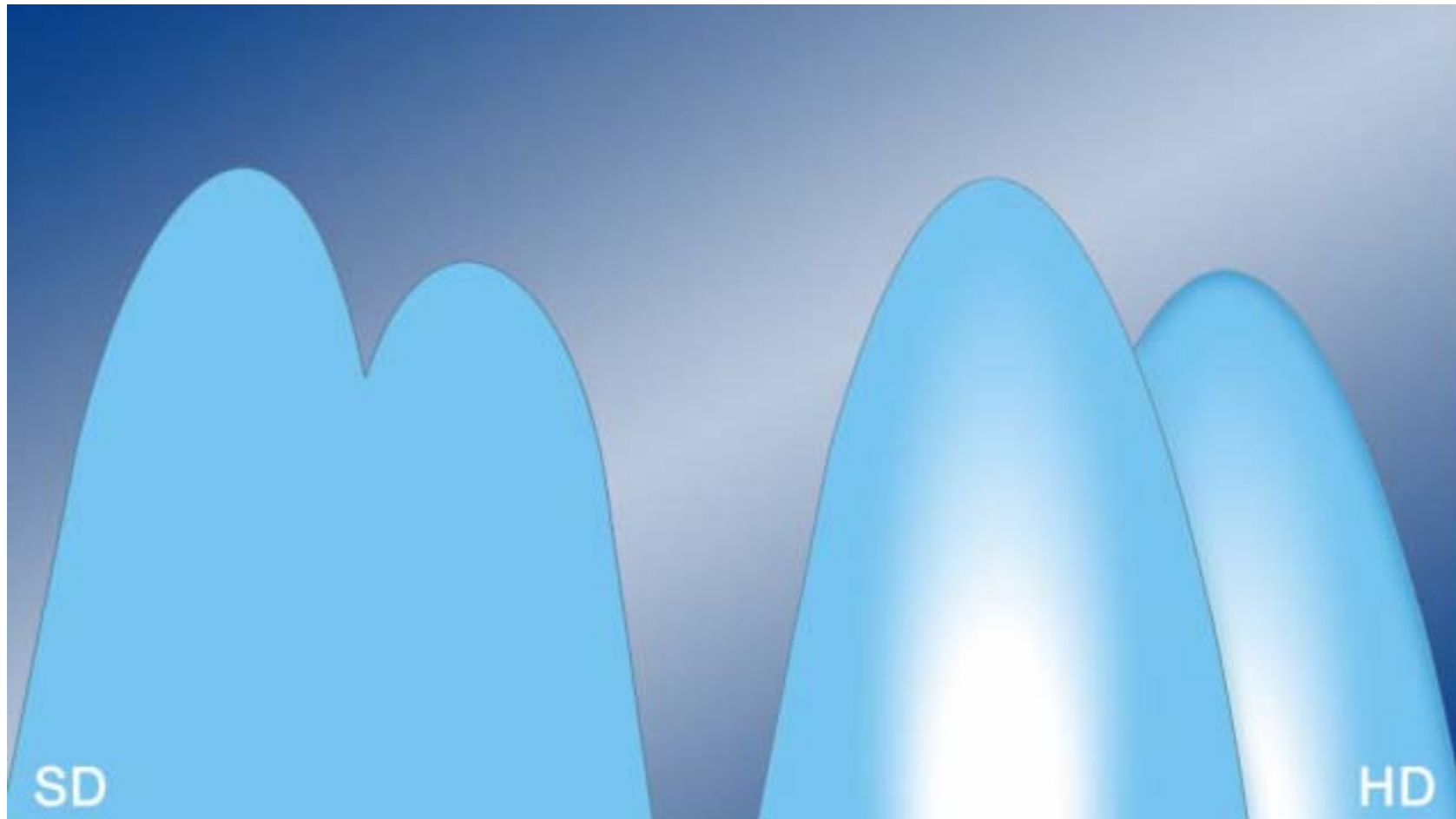
FORMATS



Resolution



Definition

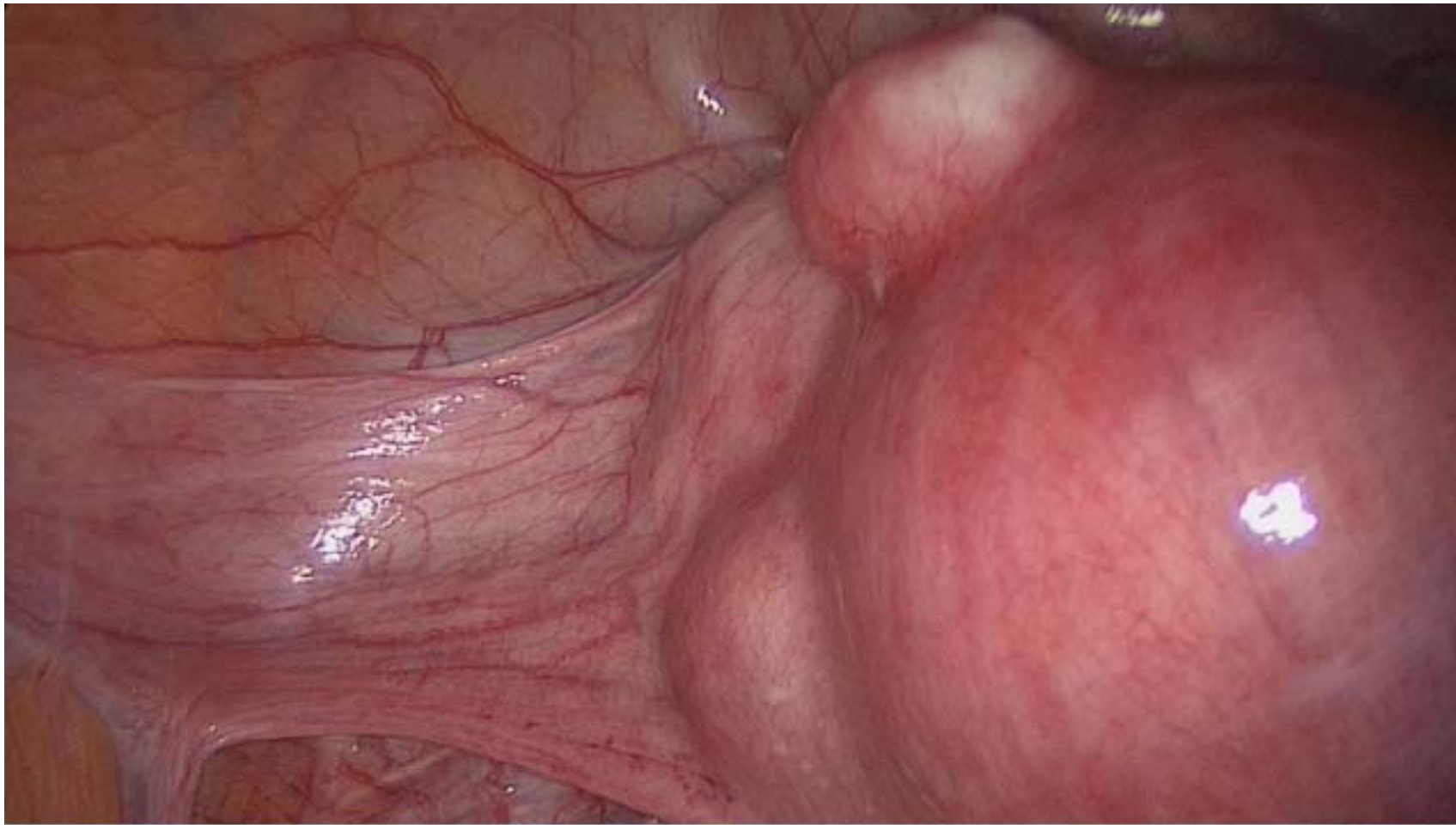


Full HD

Full HD
1080



Full HD



Full HD

- 16:9 ratio for natural vision
- 16:9 ratio provides lateral extension of field of vision
- Great color brilliance
- 1920 x 1080 offers 7 times the SD resolution at 480 lines
- Clear differentiation of tissue structures



Impeded view

Pressure	Flow	Cause
Low	High	Leak
Low	Low	Empty
High	Low	Relaxation/ Occlusion
High	High	Multifactorial/ malfunction



Energy Source

- Electrosurgery
 - Monopolar cautery
 - Bipolar cautery
- Ultrasonic



Injury from Energy Source

- Direct Coupling



Injury from Energy Source

- Indirect Coupling



Ultrasonic Coagulation

- Relies on mechanical energy to produce effects



Operating Room Set-up

- Patient positioning
- Video-endoscopic equipment
- Ancillary equipment
- Personnel



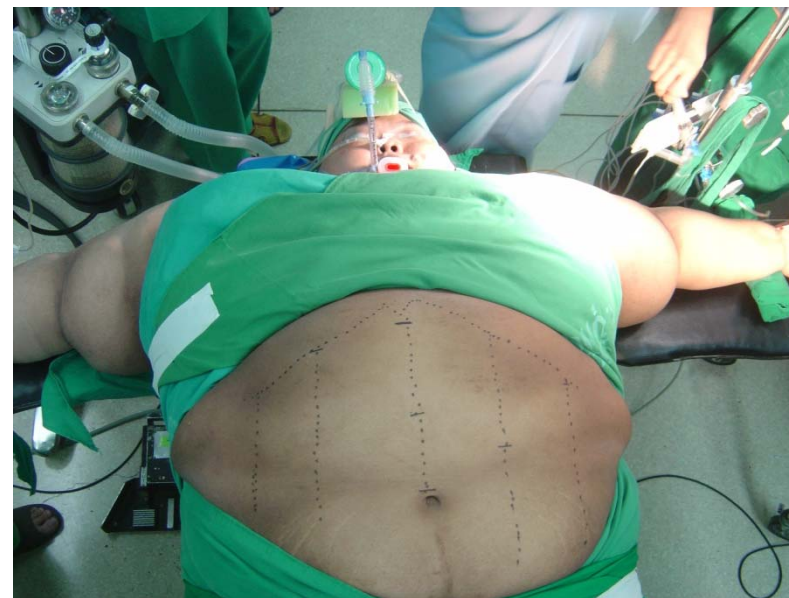
Patient Positioning

- Supine
- Lateral Decubitus
- Lithotomy



Supine

- Arms out
 - Upper abdomen
 - Incisional hernia



Supine

- Tucking arms
 - Pelvis and lower abdomen



Patient Positioning

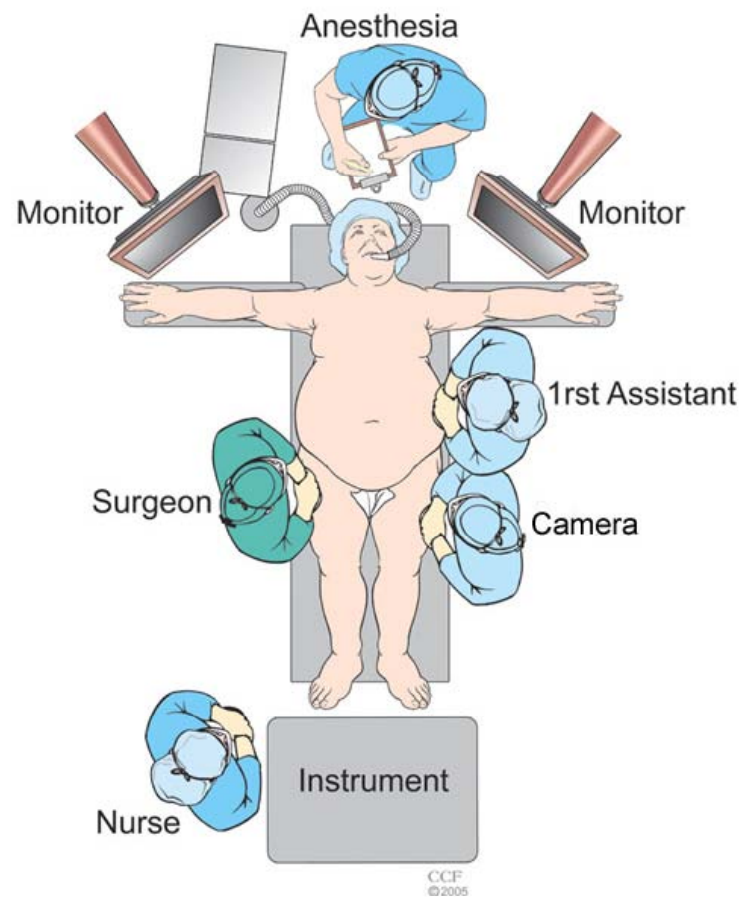
- Tendelenberg
- Reverse Tendelenberg



DVT Prevention



Personnel

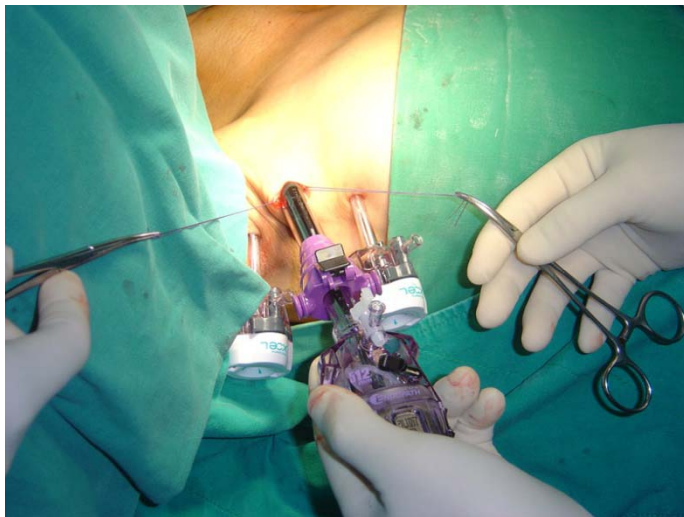
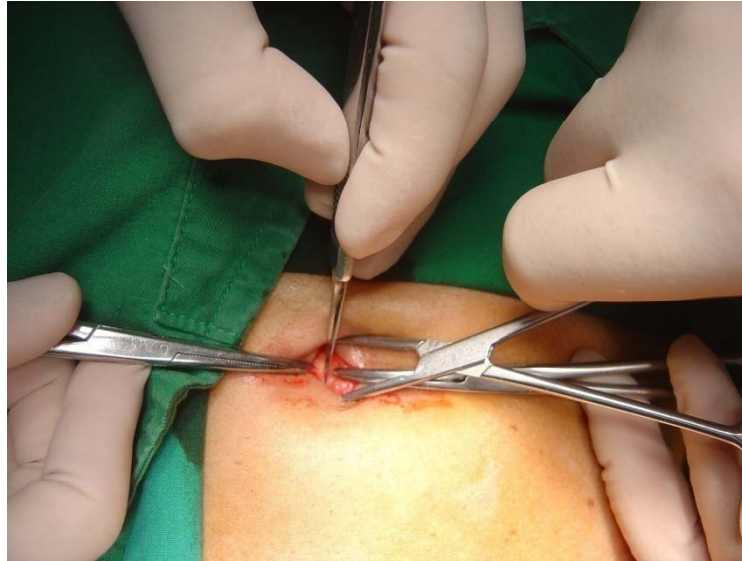


Personnel



Primary Access

- Open
“Hasson”



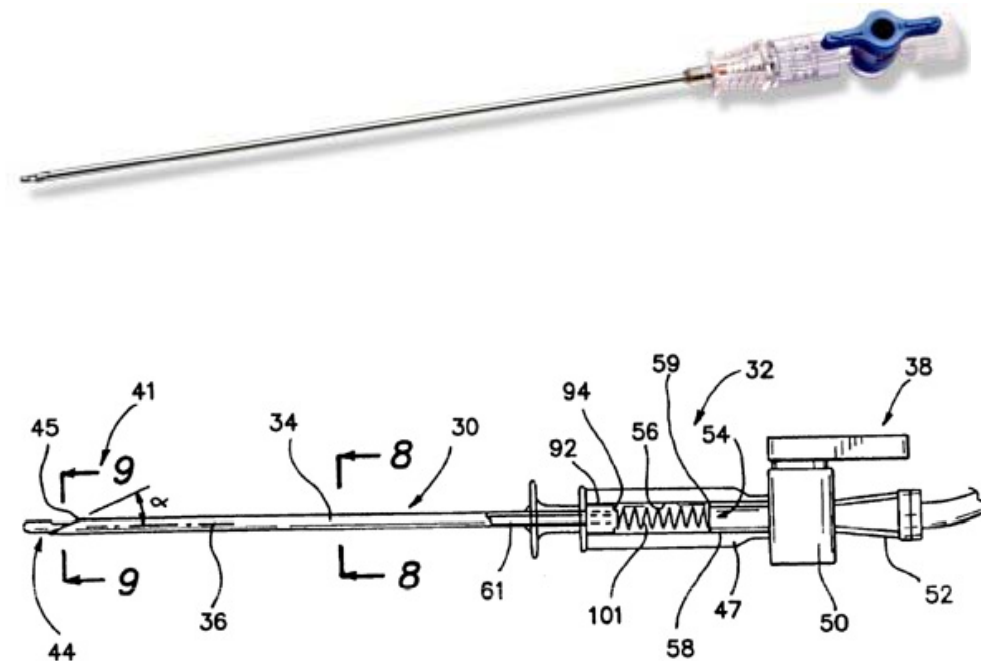
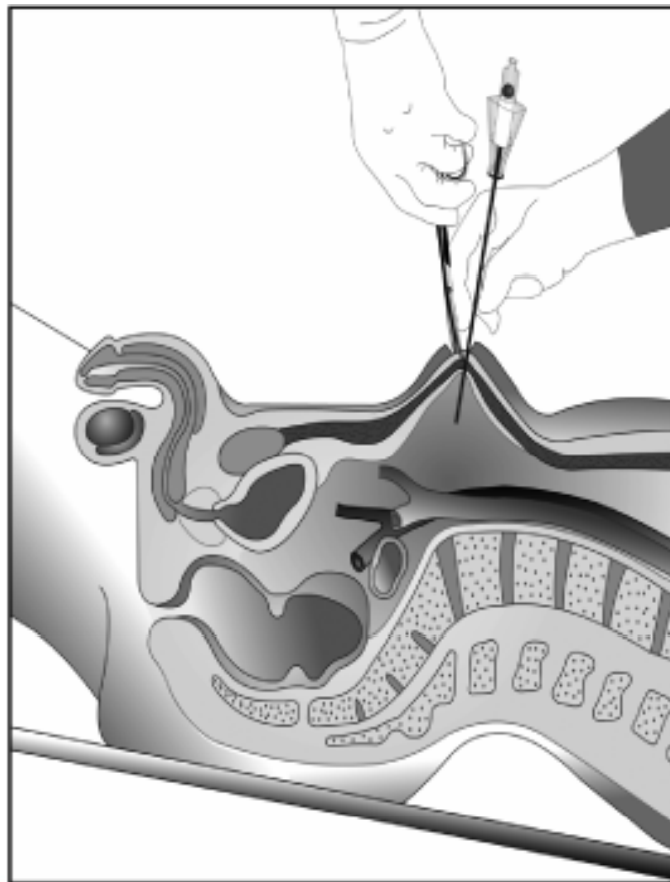
Primary Access

- Direct vision



Primary Access

- Veress Needle



Direct vs Veress (RCT)

Table 2. Results of DTI vs VN

Results	DTI ^a (n = 275)	VN ^a (n = 323)	<i>p</i> value
Success rate ^b	100%	98.7% (319/323)	NS
Failed entry ^c	0%	1.3% (4/323)	NS
Minor complications	0%	5.9% (19/323)	< 0.01
Subcutaneous emphysema	0%	3.4% (11/23)	< 0.01
Extraperitoneal insufflation	0%	2.5% (8/323)	< 0.01
Major complications	0%	1.3% (4/323)	NS
Solid organ lesions	0%	0.6% (2/323) ^d	NS
Visceral injuries	0%	0.3 (1/323) ^e	NS
Other	0%	0.3 (1/323) ^f	NS
Reintervention	0%	0.3 (1/323) ^e	NS
Gas embolism	0%	0%	NS
Mortality	0	0	NS

Surg Endosc (2004) 18: 1778–1781



Current Laparoscopic Surgery

- LC
- CBD exploration
- Anti-reflux surgery
- Achalasia
- Hernia (inguinal, ventral)
- Peptic ulcer operation
- Splenectomy
- Adrenalectomy
- Trauma
- Large and small bowel
- Appendectomy
- Gastric surgery
- Morbid obesity
- (endoscopic thyroid Sx)



Conclusion

Preoperative assessment

Patient is scheduled for laparoscopic surgery

Define patient as comorbid if:
ASA III-IV, COPD, NYHA III-IV,
CRF etc. (see text for details)

Pre-surgery interventions

Administer adequate preoperative
volume loading (grade A)

Is patient
comorbid ?

Yes

- Start invasive measurement of blood pressure or circulating volume (grade A)
- Insert urine catheter (grade B)
- Consider pharmacological interventions (e.g. β -blocker, nitroglycerin) (grade A)
- Consider gasless laparoscopy (grade B)
- In COPD patients, consider helium as alternative gas (grade B)

No

Start monitoring of end tidal
CO₂-concentrations (grade A)



Conclusion

Surgical interventions

